Claims

1.   A method of processing a plurality of A/C analog input signals derived from different sources through a first processing channel including a shared bandpass filter, integrator and A/D

5   converter, and through a plurality of second processing channels, each including resolution into orthogonal components as a function of the instantaneous angle of a corresponding one of a plurality of members rotating at different variable speeds and related to at least one of said analog input signals followed by low pass filtering, and

10   providing, for each rotating member, an average of a plurality of sums of the squares of successive ones of said components corresponding to each of said sources, said method comprising:

(a)   receiving a plurality of streams of input pulses from a plurality of angle-indicating sensors each indicative of rotation of a

15   corresponding related member, said streams being of mutually unrelated frequencies, the frequency of either or both of which may be fixed or variable;

performing steps (b) - (d) for each of said streams -

(b)   determining, for each pulse received, the particular

20   period of time between each said pulse and the next preceding pulse thereto in said stream;

(c)   determining, for each pulse received, each lapse of $1/2^n$ of said period;

(d)   providing a corresponding stream of control pulses,

25   including one control pulse for each said input pulse and $2^n - 1$ control pulses distributed between successive ones of said input pulses, and spaced by $1/2^n$ of said period in response to said second step;

performing steps (e) - (g) for at least one of said streams of control pulses in which each pulse represents a non-integer function of a revolution -

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(e)   providing a plurality of look-up tables of trigonometric values of successive counts of angles corresponding to a selected number of pulses per revolution, which selected number may either be (i) an integer or (ii) a non-integer, a small integer multiple of which

35   is an integer for which said trigonometric values repeat, and for which said trigonometric values are acceptably close to corresponding trigonometric values of angles corresponding to successive counts of said control pulses;

(f)   counting said control pulses modulo m, where m is

40   said small integer multiple of said selected number;

(g)   applying the count derived in step (f) to said look-up table, thereby to derive the desired trigonometric functions approximately corresponding to the revolutions of said sensor;

(h)   providing at least one analog input signal which is to

45   be processed to evaluate at least one parameter thereof as it relates to each of said control signal streams;

(i)   registering the occurrence of each control signal, separately for each of said streams, until completion of an A/D conversion started in step (j);

50   (j)   starting an A/D conversion in response to registration of a control signal of any stream in step (i), unless an A/D conversion is in process;

(k)   loading the result of each A/D conversion into at least one of a plurality of parameter registers, each said parameter register

55   related independently to one of said plurality of control signal streams, said step of loading into at least one of said plurality of

registers being responsive to completion of an A/D conversion concurrently with the registration of said step (i) of a control signal of a corresponding one of said streams, whereby if one of said control

60   signals occurs while a particular A/D conversion is in process, the result of said particular A/D conversion will be loaded into one of said registers corresponding to said one timing signal as well as the one of said registers corresponding to the control signal which actually started said particular A/D conversion in said step (j);

65   (l)   providing at least one square wave signal, each having a frequency within a range of frequencies of said A/C input signals and a magnitude related to a range of magnitudes of the related one of said A/C input signals;

          (m)   periodically selecting either an analog input signal

70   from one of said sources or said square wave signal for application to said processing channels;

          (n)   defining a processing period within which said average is to be provided corresponding to the signal selected in step (m) after the output of said bandpass filter and integrator have

75   settled on a value of the selected one of said signals following step (m);

          (o)   determining a given rate of deceleration which said members may undergo;

          (p)   determining, for each of said members, the time

80   required to provide said average corresponding to said each member when said each member undergoes said given rate of deceleration from the corresponding current instantaneous speed of said member during said processing period;

          (q)   providing for each member, a start signal at a point in

85   time advanced from the end of said processing period by said

corresponding time required to provide said average, the time within said processing period preceding said start signal allowing settling of signals at the A/D converter input, each said start signal causing accumulation of said corresponding plurality of sums so that an

90   average of each accumulation may be provided; and

(r)   determining in response to said sums of the squares of successive ones of said components corresponding to said square wave test signal, the viability of processing through said processing channels.

2.   Apparatus for multiplying the frequency of pulses, in a stream of input pulses, by 2^n, comprising:

means for receiving pulses in said stream;

first means for determining, for each pulse received, the

5   particular period of time between said each pulse and the next preceding pulse thereto in said stream;

second means for determining, for each pulse received, each lapse of $1/2^n$ of said period; and

third means for providing a stream of output pulses, including

10   one output pulse for each said input pulse and 2^n-1 output pulses distributed between successive ones of said input pulses, and spaced by $1/2^n$ of said period in response to said second means.

3.   Apparatus according to claim 2 wherein said third means comprises:

means for issuing into a stream of output pulses, one output pulse upon each occurrence of determining said lapse, except the last

5   occurrence related to each said input pulse, and one output pulse in response to each said input pulse, whereby 2^n-1 output pulses are

inserted in said stream of output pulses between successive input pulses.

4.   Apparatus according to claim 3 comprising:

a source providing clock signals; and wherein said means for providing comprises:

a first counter for counting said clock signals during one
5   period between input signals in said stream, to provide a count;

a register for maintaining the count of said clock signals divided by n during a second period between input signals in said stream next subsequent to said one period;

a second counter for counting clock signals;
10   a comparator for comparing the count in said second counter with the count in said register to provide a pulse for said output stream each time said counts are equal; and

means for preventing said second counter from counting more than 2^n-1 times between each said input pulse.

5.   A method of multiplying the frequency of pulses in a stream of input pulses by 2^n, comprising:

receiving pulses in said stream;

first, determining, for each pulse received, the particular
5   period of time between said each pulse and the next preceding pulse thereto in said stream;

second, determining, for each pulse received, each lapse of $1/2^n$ of said period; and

third, providing a stream of output pulses, including one
10   output pulse for each said input pulse and 2^n-1 output pulses

distributed between successive ones of said input pulses, and spaced by $1/2^n$ of said period in response to said second step.

6.   A method according to claim 5 wherein said means for providing comprises:

issuing into a stream of output pulses, one output pulse upon each occurrence of determining said lapse, except the last occurrence 5   related to each said input pulse, and one output pulse in response to said each input pulse, whereby 2^n-1 output pulses are inserted in said stream of output pulses between successive input pulses.

7.   Apparatus for digitally compensating for a non-integer number of pulses-per-revolution from an angle-indicating sensor indicative of rotation of a related thing, said method comprising:

(a)   means for providing a look-up table of trigonometric 5   values of successive counts of angles corresponding to a selected number of pulses per revolution, which selected number may either be (i) an integer or (ii) a non-integer and has a small integer multiple which is an integer for which said trigonometric values repeat, and for which said trigonometric values are acceptably close to 10   corresponding trigonometric values of angles corresponding to successive counts of said input pulses;

(b)   means for counting said input pulses modulo m, where m is said small integer multiple of said selected number; and

(c)   means for applying the count derived in element (b) to 15   said look-up table, thereby to derive the desired trigonometric functions approximately corresponding to the revolutions of said sensor.

8.   A method of digitally compensating for non-integer pulses-per-revolution input pulses from an angle-indicating sensor indicative of rotation of a related thing, said method comprising:

(a)   providing a look-up table of trigonometric values of successive counts of angles corresponding to a selected number of pulses per revolution, which selected number may either be (i) an integer or (ii) a non-integer, and a small integer multiple of which is an integer for which said trigonometric values repeat, and for which said trigonometric values are acceptably close to corresponding trigonometric values of angles corresponding to successive counts of said input pulses;

(b)   counting said input pulses modulo m, where m is said small integer multiple of said selected number; and

(c)   applying the count derived in step (b) to said look-up table, thereby to derive the desired trigonometric functions approximately corresponding to the revolutions of said sensor.

9.   A method of converting analog signals to digital signals in an A/D converter at a plurality of different sampling rates simultaneously, said method comprising:

(a)   providing a plurality of sampling timing signal streams of mutually unrelated frequencies, the frequency of either or both of which may be fixed or variable;

(b)   providing an analog input signal which is to be processed to evaluate at least one parameter thereof as it relates to both of said sampling timing signal streams;

(c)   registering the occurrence of each timing signal, separately for each of said streams, until completion of an A/D conversion started in step (d);

(d)   starting an A/D conversion in response to registration of a timing signal of any stream in step (c), unless an A/D conversion is in process; and

(e)   loading the result of each A/D conversion into at least one of a plurality of registers, each said register related independently to one of said plurality of timing signal streams, said step of loading into each one of said plurality of registers being responsive to completion of an A/D conversion concurrently with the registration of said step (c) of a timing signal of a corresponding one of said streams, whereby if one of said sampling timing signals occurs while a particular A/D conversion is in process, the result of said particular A/D conversion will be loaded into the register corresponding to said one timing signal as well as the register corresponding to the timing signal which actually started said particular A/D conversion in said step (d).

10.   Apparatus for converting analog signals to digital signals in an A/D converter at a plurality of different sampling rates simultaneously, comprising:

(a)   means for providing a plurality of timing signal streams of different frequencies, the frequency of either or both of which may be fixed or variable;

(b)   means for providing an analog signal which is to be processed to evaluate at least one parameter thereof as it relates to both of said sampling timing signal streams;

(c)   means for registering the occurrence of each timing signal, separately for each of said streams, until completion of an A/D conversion started in element (d);

(d)   means for starting an A/D conversion in response to registration of a timing signal of any stream in element (c) unless an A/D conversion is in process;

(e)   means for loading the result of each A/D conversion into at least one of a plurality of registers, each said register related independently to one of said plurality of timing signal streams, said step of loading into at least one of said plurality of registers being responsive to completion of an A/D conversion concurrently with the registration by said element (c) of a timing signal of a corresponding one of said streams, whereby if one of said sampling timing signals occurs while a particular A/D conversion is in process, the result of said particular A/D conversion will be loaded into the register corresponding to said one timing signal as well as the register corresponding to the timing signal which actually initiated said particular A/D conversion in said element (d).

11.   Apparatus for converting an analog signal to a digital signal at a plurality of different sampling rates simultaneously, comprising:

an A/D converter;

at least one sensor, each sensor providing an analog signal indicative of a condition of a corresponding part;

a plurality of rotation sensors, each related to a corresponding rotating portion of said part, each providing a stream of sampling timing signals, each signal of each stream representing a known fraction, which may be an integral fraction or a non-integral fraction, of a revolution of the corresponding rotating part;

at least one latch, each responsive to said sampling timing signals from a corresponding one of said rotation sensors to assume

a first state and to simultaneously provide a start signal to said A/D

15   converter;

        a plurality of registers, one for each of said rotation sensors;

        a plurality of means, one for each of said rotation sensors,

each responsive to completion of an A/D conversion by said A/D

converter, concurrently with the related latch being set in said first

20   state, to set the corresponding latch into a state other than said first

state and to cause the result of said A/D conversion to be stored in

the related one of said registers, whereby if one of said sampling

timing signals occurs while a particular A/D conversion is in process,

the result of said particular A/D conversion will be loaded into the

25   register corresponding to said one timing signal as well as the register

corresponding to the timing signal which actually initiated said

particular A/D conversion.

        12.   A method of processing a plurality of input signals

derived from different sources through a processing channel including

a shared bandpass filter, integrator, A/D converter, and resolution

into orthogonal components as a function of the instantaneous angle

5   of a member, rotating at variable speed and related to at least one of

said input signals, and providing an average of a plurality of sums of

the squares of successive ones of said components corresponding to

one of said sources, said method comprising:

        (a)   switching said processing channels from a first one of

10   said sources to a second one of said sources;

        (b)   defining a processing period within which said

average is to be provided corresponding to said second source after

the output of said bandpass filter and integrator have settled on a

value of one of said input signals from said second source following

15 step (a);

determining a given rate of deceleration which said member may undergo;

determining the time required to provide said average when said member undergoes said rate of deceleration from the current

20 instantaneous speed during said processing period; and

providing a start signal at a point in time advanced from the end of said processing period by said time required to provide said average, the time preceding said start signal allowing setting of said value, said start signal causing accumulation of said plurality of sums

25 so that an average thereof may be provided.

13. Apparatus for processing a plurality of input signals derived from different sources through a processing channel including a shared bandpass filter, integrator, A/D converter, and resolution into orthogonal components as a function of the instantaneous angle

5 of a member, rotating at variable speed and related to at least one of said input signals, and providing an average of a plurality of sums of the squares of successive ones of said components corresponding to one of said sources, comprising:

(a) means for switching said processing channels from a

10 first one of said sources to a second one of said sources;

(b) means for defining a processing period within which said average is to be provided corresponding to said second source after the output of said bandpass filter and integrator have settled on a value of one of said input signals from said second source following

15 step (a);

means for determining a given rate of deceleration which said member may undergo;

means for determining the time required to provide said average when said member undergoes said rate of deceleration from the current instantaneous speed during said processing period; and

means for providing a start signal at a point in time advanced from the end of said processing period by said time required to provide said average, the time preceding said start signal allowing setting of said value, said start signal causing accumulation of said plurality of sums so that an average thereof may be provided.

14.   A method of testing the viability of processing of an AC input signal, having a magnitude, through a processing channel including a shared bandpass filter and integrator, A/D converter, and resolution into orthogonal components as a function of the instantaneous angle of a member, rotating at variable speed and related to said input signal, and providing sums of the squares of successive ones of said components corresponding to said input signal, said method comprising:

providing a square wave signal having a frequency corresponding to frequencies of interest of said AC input signal and a magnitude of $4/\pi$ of a corresponding magnitude of interest of said AC input signal;

periodically selecting said square wave signal instead of said input signal for application to said processing channel; and

determining, in response to said sums of the squares of successive ones of said components corresponding to said square wave test signal, the viability of processing through said processing channel.

15.   A method of testing the viability of processing of an AC input signal having a range of magnitudes and a range of frequencies, through a processing channel including a low pass filter, said method comprising:

5   providing a square wave signal having a frequency within said range of frequencies and a magnitude related to said range of magnitudes;

periodically selecting said square wave signal instead of said input signal for application to said processing channel; and

10   determining, in response to the output of said processing channel corresponding to said selected wave signal, the viability of processing through said processing channel.

16.   A method according to claim 14 wherein:

said providing step provides a plurality of square wave signals at diverse frequencies within said range of frequencies; and

said selecting step includes selecting one of said plurality of

5   square wave signals.

17.   Apparatus for testing the viability of processing of an AC input signal having a range of magnitudes and a range of frequencies, through a processing channel including a low pass filter, comprising:

5   means for providing a square wave signal having a frequency within said range of frequencies and a magnitude related to said range of magnitudes;

means for periodically selecting said square wave signal instead of said input signal for application to said processing channel; and

means for determining, in response to the output of said processing channel corresponding to said selected wave signal, the viability of processing through said processing channel.